1998 TOPEX/Poseidon/Jason-1 Science Working Team Meeting

Keystone, Colorado

October 13, 1998

G. S. Hayne and D. W. Hancock III
Observational Science Branch
NASA GSFC/Wallops Flight Facility
Wallops Island, VA 23337

Observations from Long-Term Performance Monitoring of the TOPEX Radar Altimeter

G. S. Hayne and D. W. Hancock III
NASA GSFC/Wallops Flight Facility
Observational Science Branch
Wallops Island, VA 23337
phone: 757-824-1294; fax: 757-824-1036; email: hayne@osb.wff.nasa.gov)

From the August 1992 launch to the present, we have conducted performance analysis and engineering assessment for the TOPEX radar altimeter. We continually update entire-mission databases containing: i) on-board engineering parameters such as temperatures, voltages, and currents; ii) internal calibration mode indications of bias changes in range (Figure 1) and power estimates; and iii) global over-ocean averages of geophysical quantities such as significant waveheight (SWH) and such as the ocean surface radar backscattering cross-section (sigma0) depicted in Figures 2 and 3.

For some time, we have seen an apparent increase in the TOPEX cycle-average SWH (Figure 4), amounting now to an increase of about 10% >from our earlier mission value of about 2.8 m. Recently several investigators have reported that the TOPEX SWH is increasing relative to ERS-2 and to ocean buoy measurements. Detailed examination of early-mission TOPEX waveforms and recent waveforms show distinct change in the waveforms' leading edge, as seen in Figures 5 and 6. We examined the past six years of waveform data from an internal calibration mode (Cal 1) which samples the altimeter's point target response (PTR), and found that the PTR sidelobes are apparently greater now than at the start of the mission indicating a slow drift (gradual change) with time. On 08 September 1998, a special command sequence operated the TOPEX altimeter in a special test mode (Cal Sweep) giving a more detailed view of the PTR than is obtained from the normal Cal 1. The September 1998 Cal Sweep data were compared with similar data >from a 1991 preflight Cal Sweep, and this Cal Sweep comparison confirms in more detail the PTR changes shown by the Cal 1 data (Figures 7 and 8).

Modeling studies indicate that the apparent PTR changes can account for most of the increase in the TOPEX SWH estimate (Figure 9), and our modeling corresponds with the recent waveforms. That is, the SWH increase is not real, but is the result of a systematic drift within the altimeter. Our modeling indicates about a centimeter change in TOPEX range estimates as a result solely of the PTR changes seen to date (Figure 10). However, there will be an additional change in TOPEX ranges because the electromagnetic bias (EM bias) correction is a function of the SWH (Figure 11); an erroneously large SWH estimate will produce too large an EM bias correction. The resulting net error is the sum of the PTR change effect that needs to be applied and the error in the EM bias correction that was applied (Figure 12). We are developing an approximate recipe for correcting the TOPEX SWH values (Figure 13), correcting the range values (Figure 14), and correcting the resulting net range estimate consequences (Figure 15). This information will be made available on our web site (http://topex.wff.nasa.gov/).

We emphasize that any radar altimeter is a complex system requiring continuing calibration and monitoring throughout its entire lifetime.

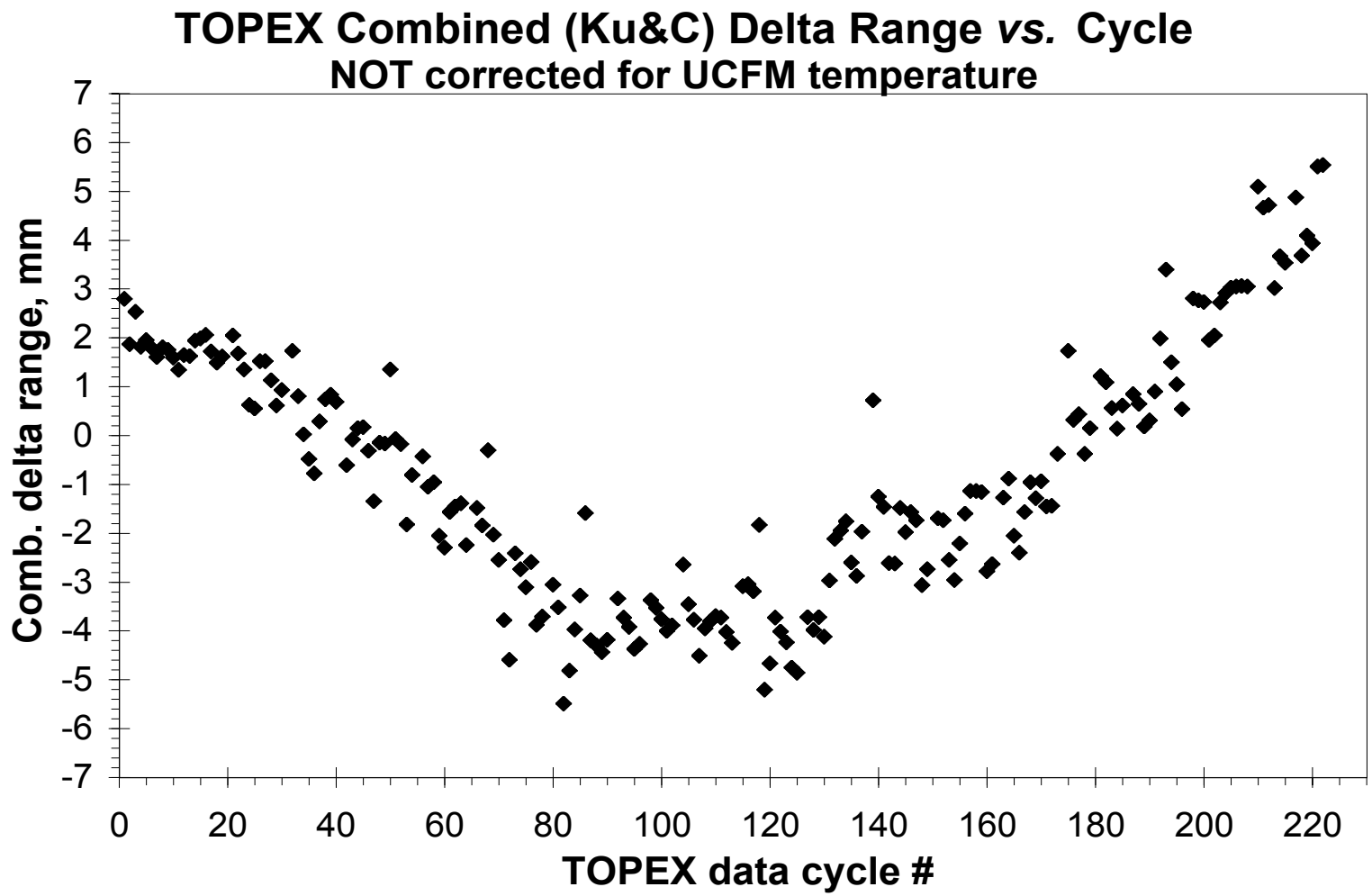
TOPEX Combined (Ku&C) Delta Range *vs.* Cycle
NOT corrected for UCFM temperature
Comb. delta range, mm
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
0
20
40
60
80
100
120
140
160
180
200
220
TOPEX data cycle #

Figure 1

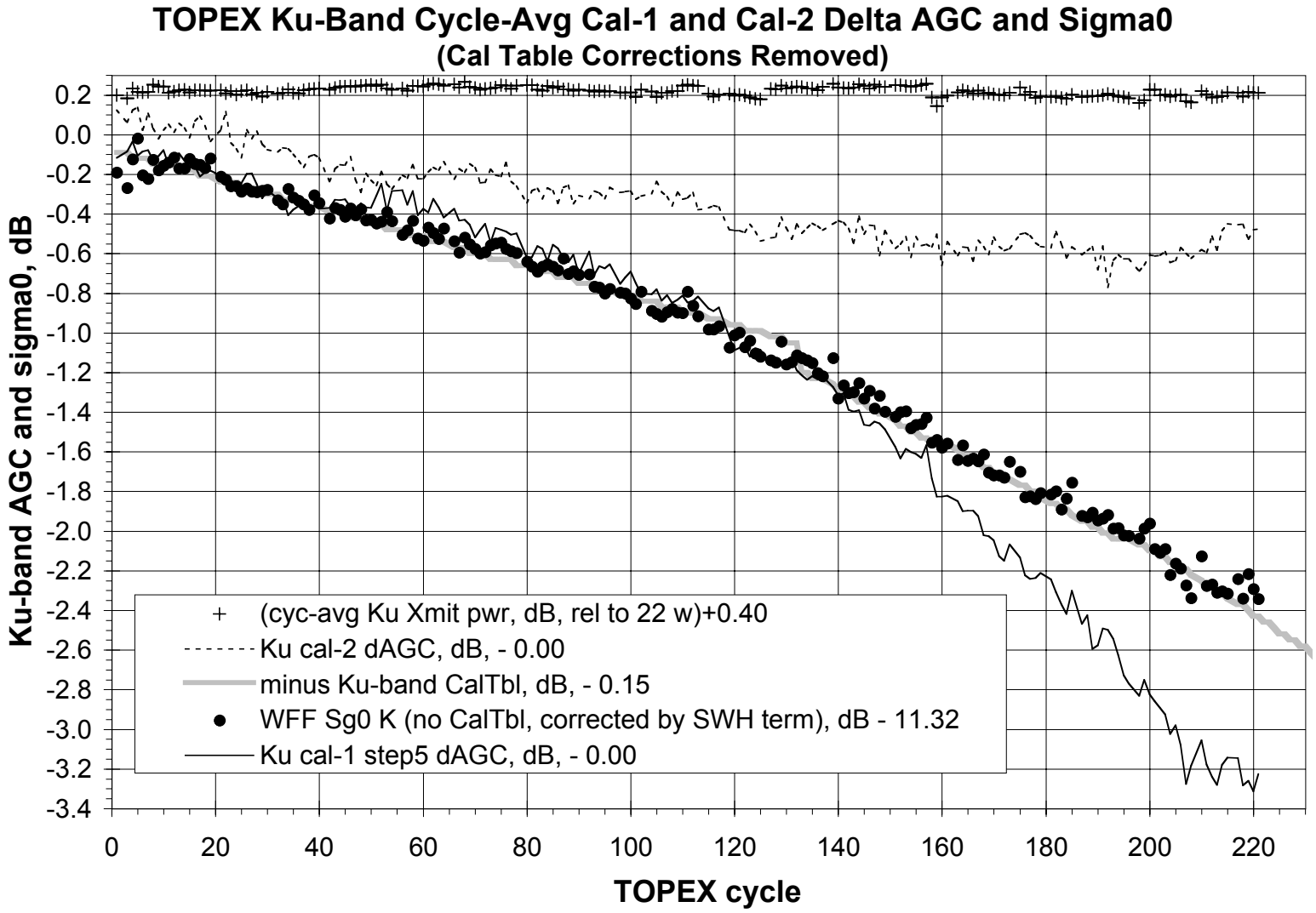
TOPEX Ku-Band Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0
(Cal Table Corrections Removed)
Ku-band AGC and sigma0, dB
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
-3.2
-3.4
0
20
40
60
80
100
120
140
160
180
200
220
TOPEX cycle
(cyc-avg Ku Xmit pwr, dB, rel to 22 w)+0.40
Ku cal-2 dAGC, dB, - 0.00
minus Ku-band CalTbl, dB, - 0.15
WFF Sg0 K (no CalTbl, corrected by SWH term), dB - 11.32
Ku cal-1 step5 dAGC, dB, - 0.00

Figure 2

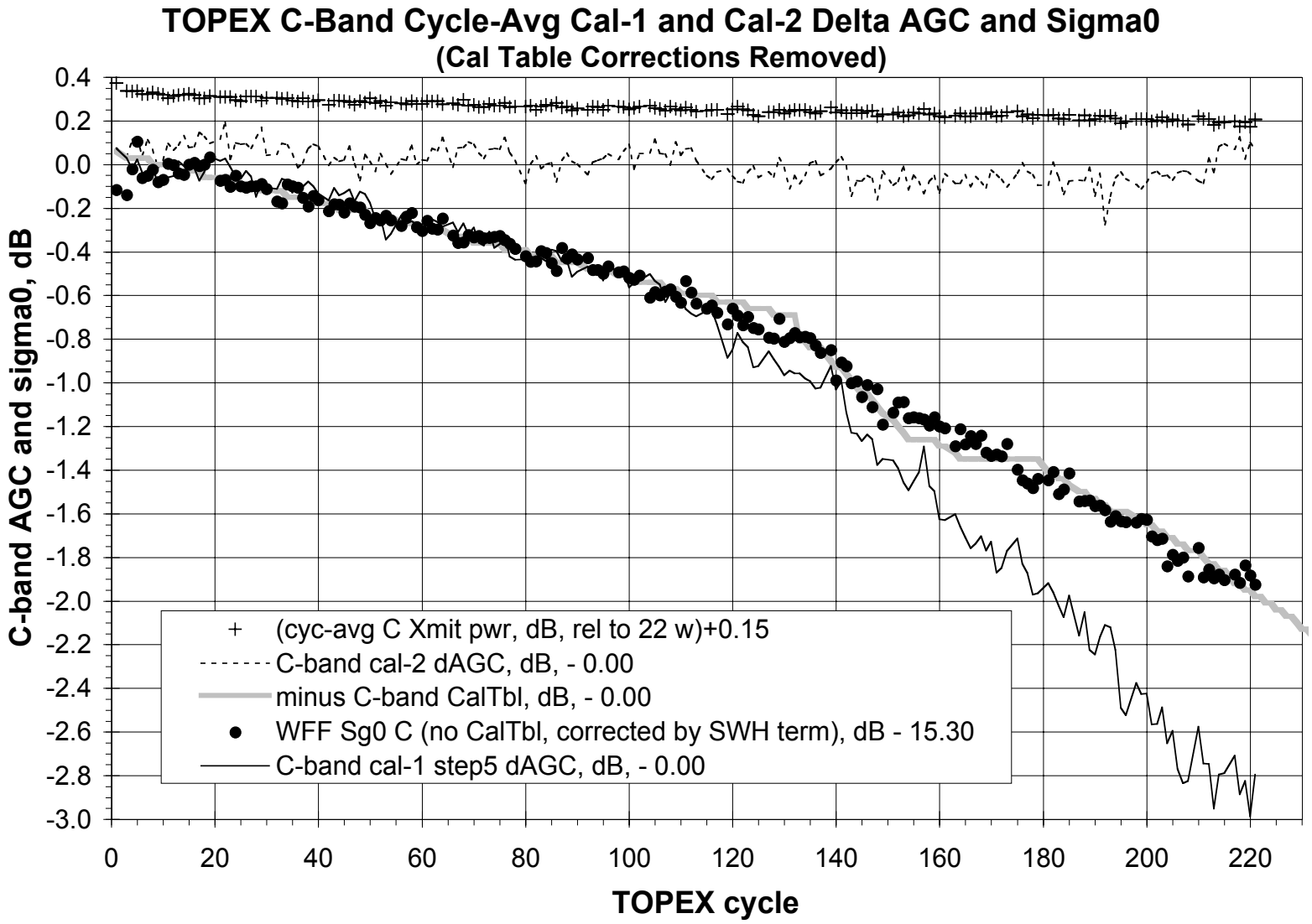
TOPEX C-Band Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0
(Cal Table Corrections Removed)
C-band AGC and sigma0, dB
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
0
20
40
60
80
100
120
140
160
180
200
220
TOPEX cycle
(cyc-avg C Xmit pwr, dB, rel to 22 w)+0.15
C-band cal-2 dAGC, dB, - 0.00
minus C-band CalTbl, dB, - 0.00
WFF Sg0 C (no CalTbl, corrected by SWH term), dB - 15.30
C-band cal-1 step5 dAGC, dB, - 0.00

Figure 3

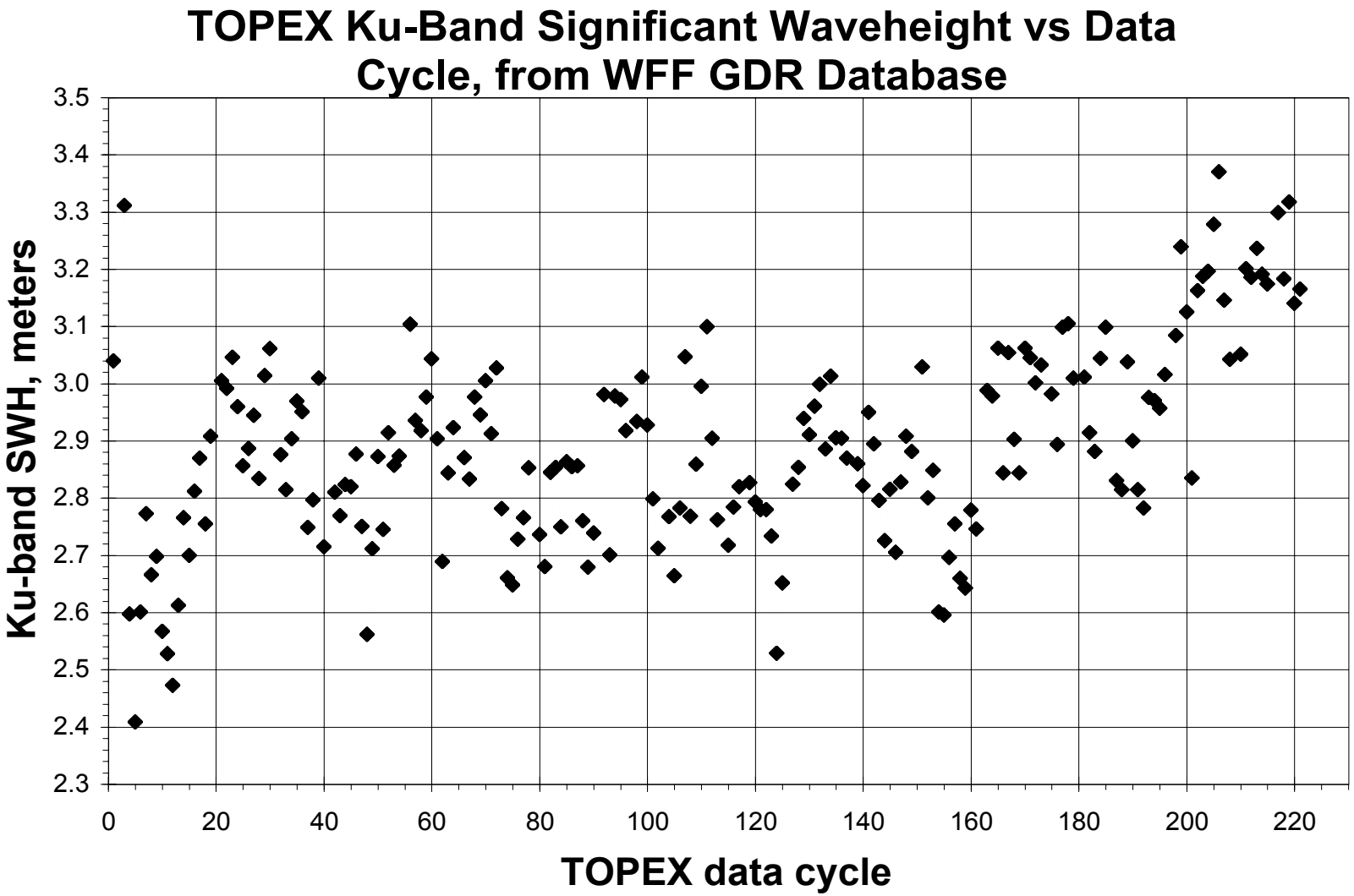
TOPEX Ku-Band Significant Waveheight vs Data Cycle, from WFF GDR Database
Ku-band SWH, meters
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
0
20
40
60
80
100
120
140
160
180
200
220
TOPEX data cycle

Figure 4

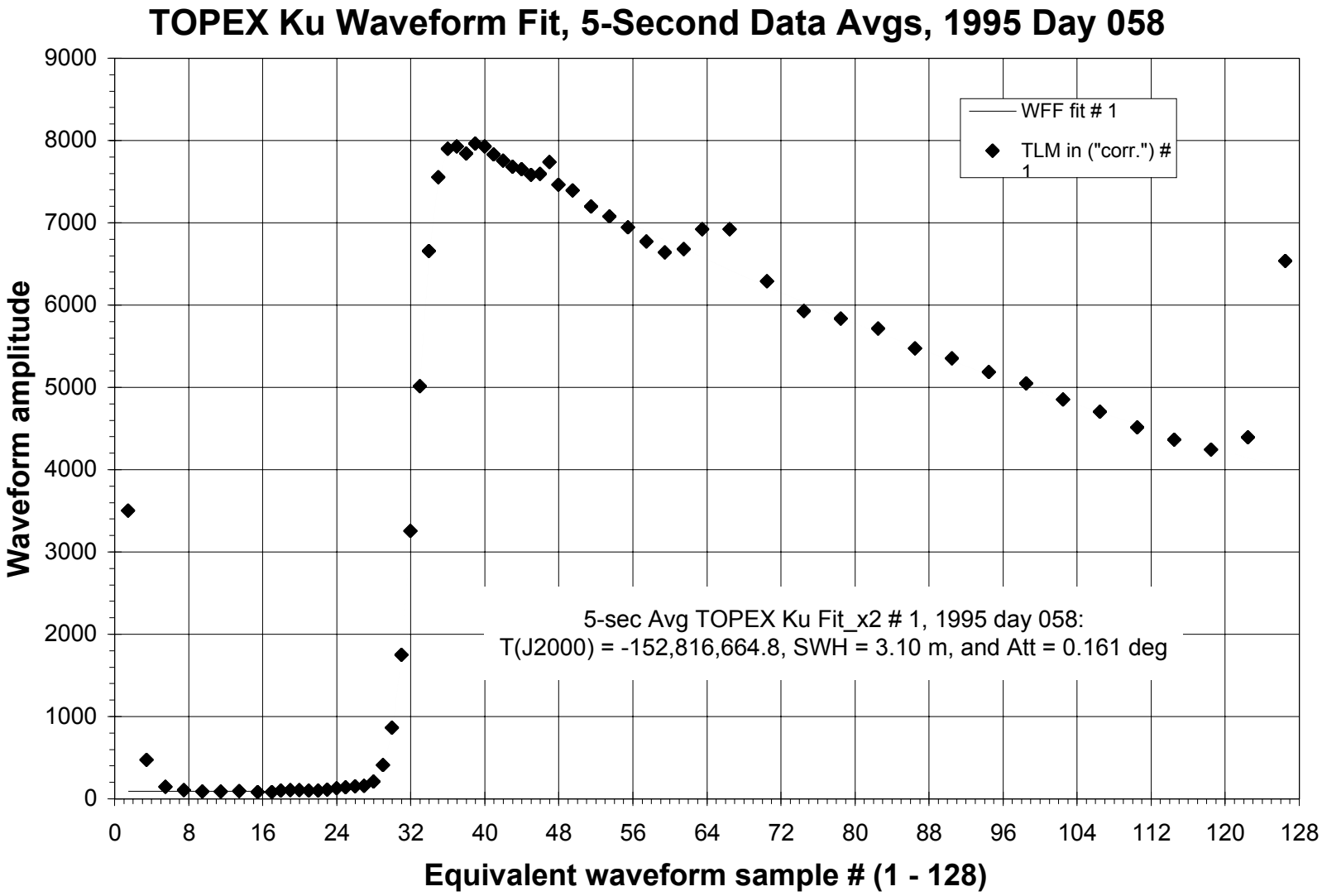
TOPEX Ku Waveform Fit, 5-Second Data Avgs, 1995 Day 058
Waveform amplitude
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
128
Equivalent waveform sample # (1 - 128)
WFF fit # 1
TLM in ("corr.") # 1
5-sec Avg TOPEX Ku Fit_x2 # 1, 1995 day 058:
T(J2000) = -152,816,664.8, SWH = 3.10 m, and Att = 0.161 deg

Figure 5

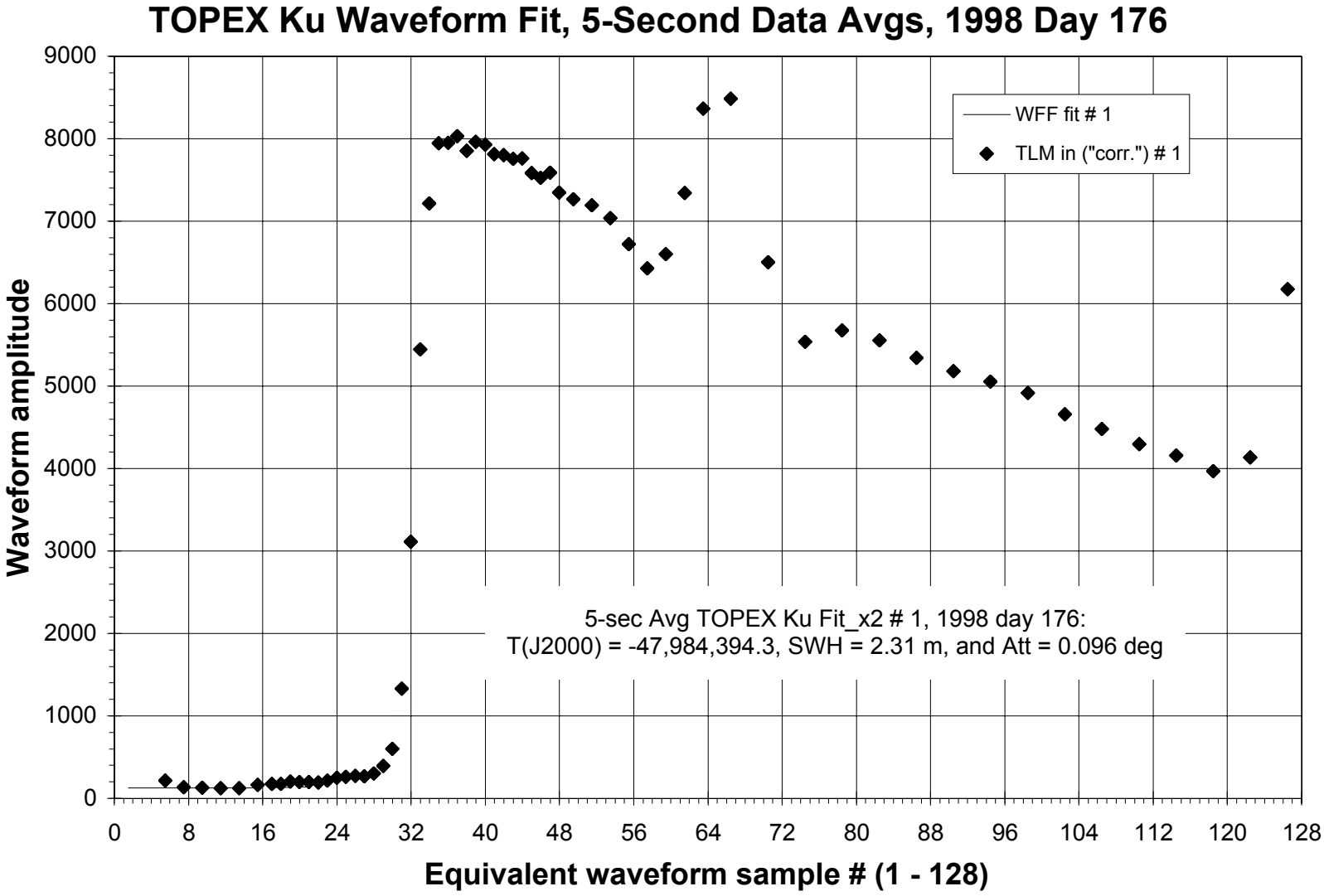
TOPEX Ku Waveform Fit, 5-Second Data Avgs, 1998 Day 176
Waveform amplitude
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
128
Equivalent waveform sample # (1 - 128)
WFF fit # 1
TLM in ("corr.") # 1
5-sec Avg TOPEX Ku Fit_x2 # 1, 1998 day 176:
T(J2000) = -47,984,394.3, SWH = 2.31 m, and Att = 0.096 deg

Figure 6

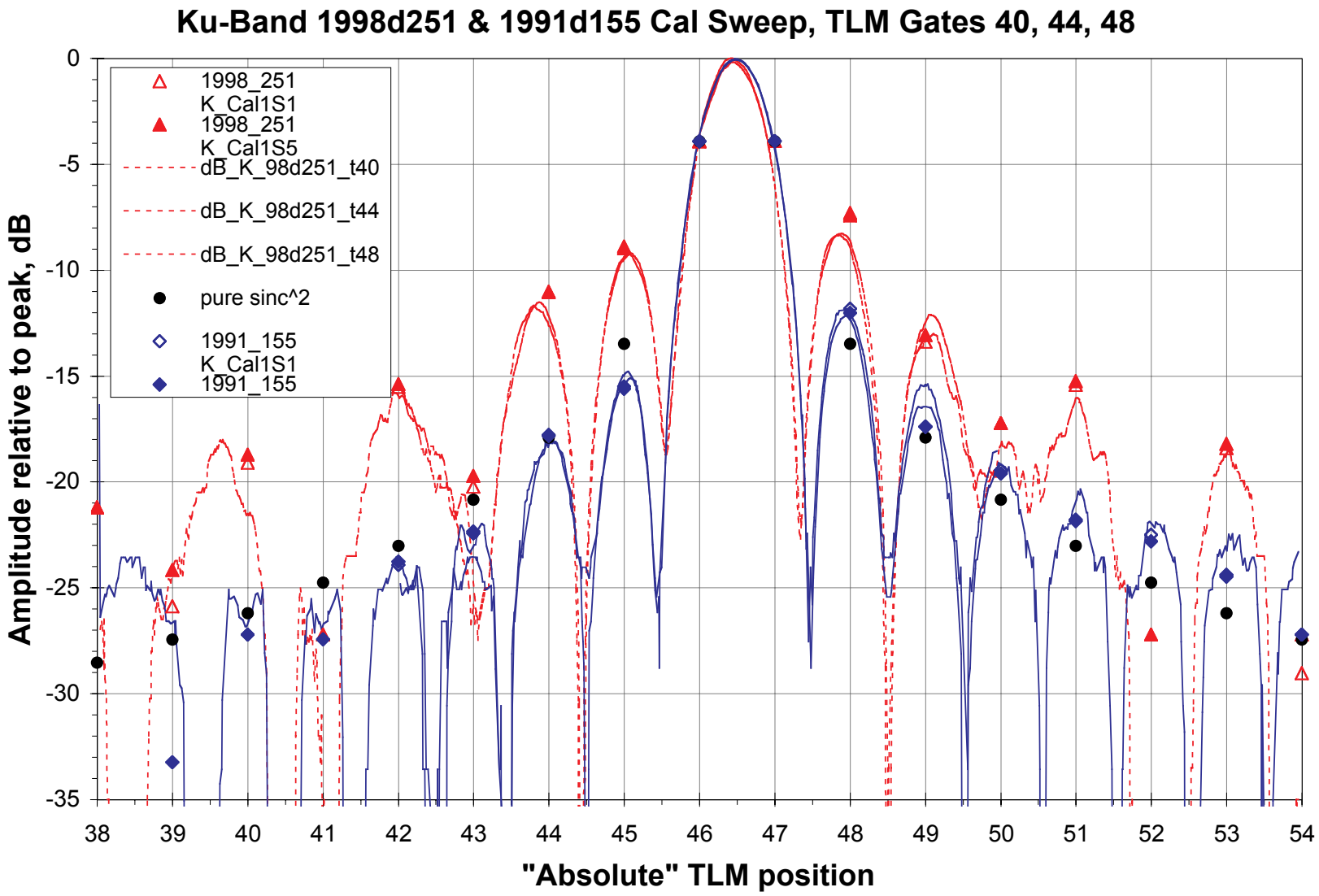
Ku-Band 1998d251 & 1991d155 Cal Sweep, TLM Gates 40, 44, 48
1998_251 K_Cal1S1
1998_251 K_Cal1S5
dB_K_98d251_t40
dB_K_98d251_t44
dB_K_98d251_t48
pure sinc^2
1991_155 K_Cal1S1
1991_155
Amplitude relative to peak, dB
0
-5
-10
-15
-20
-25
-30
-35
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
"Absolute" TLM position

Figure 7

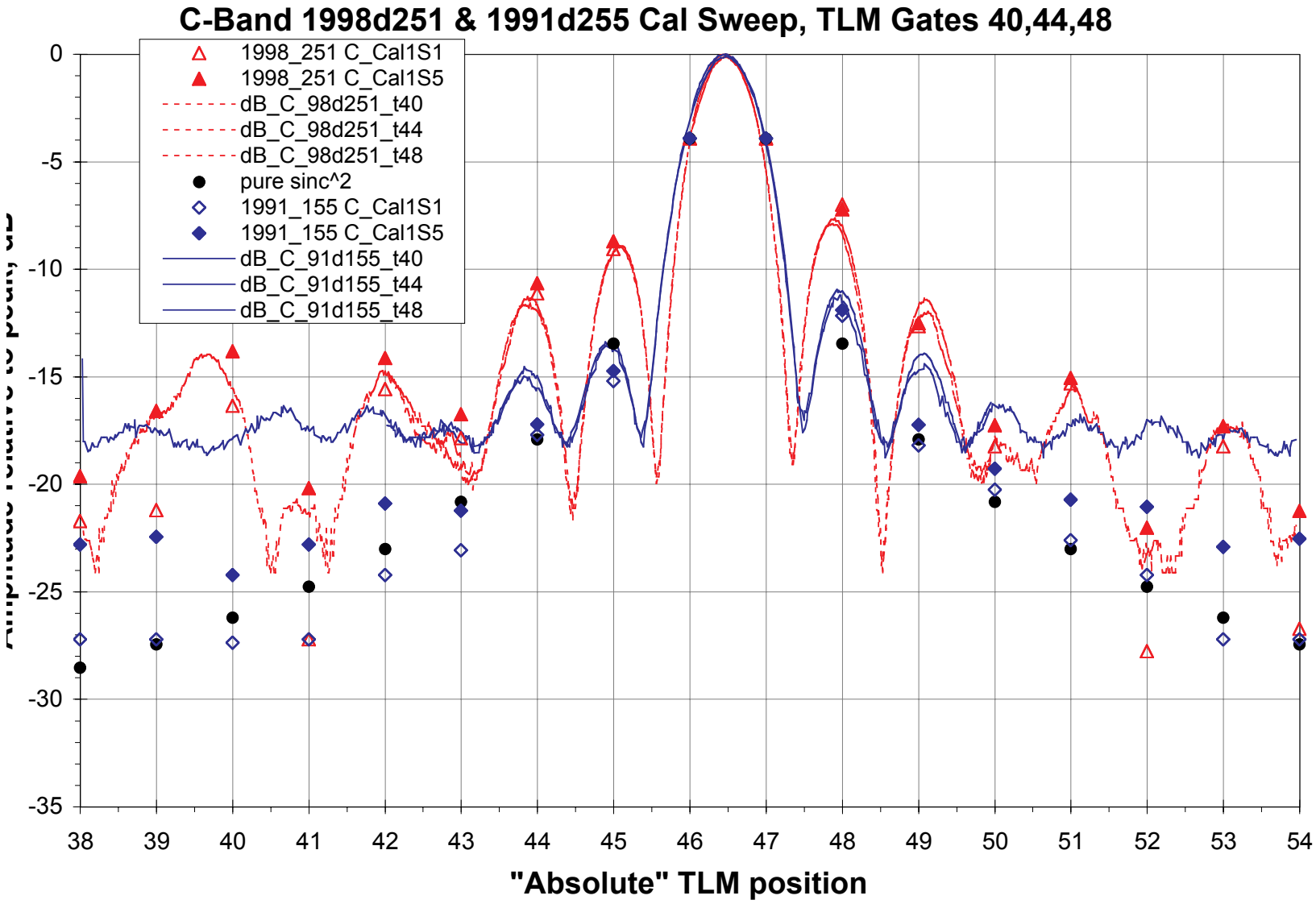
C-Band 1998d251 & 1991d255 Cal Sweep, TLM Gates 40,44,48
1998_251 C_Cal1S1
1998_251 C_Cal1S5
dB_C_98d251_t40
dB_C_98d251_t44
dB_C_98d251_t48
pure sinc^2
1991_155 C_Cal1S1
1991_155 C_Cal1S5
dB_C_91d155_t40
dB_C_91d155_t44
dB_C_91d155_t48
Amplitude relative to peak, dB
0
-5
-10
-15
-20
-25
-30
-35
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
"Absolute" TLM position

Figure 8

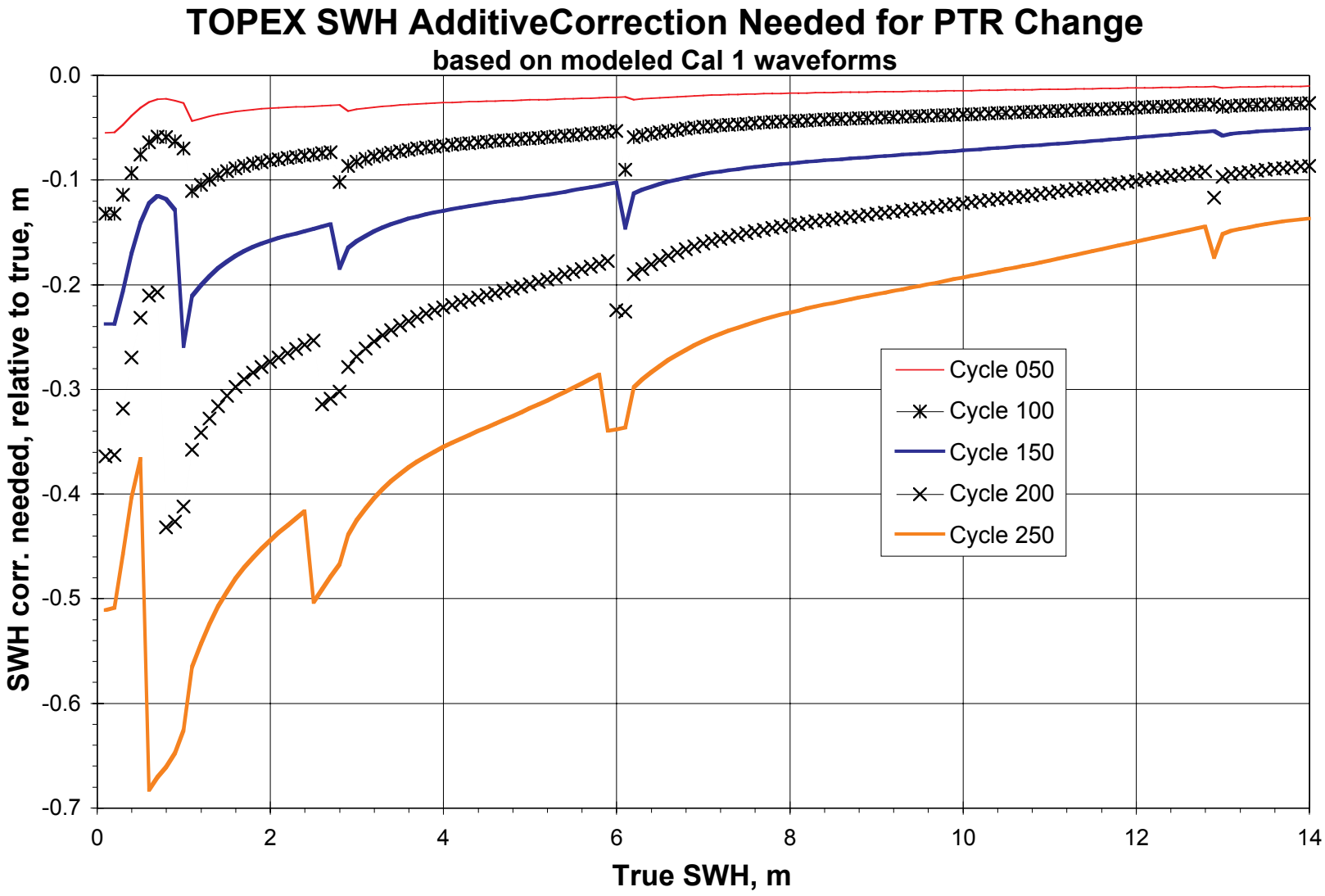
TOPEX SWH AdditiveCorrection Needed for PTR Change
based on modeled Cal 1 waveforms
SWH corr. needed, relative to true, m
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
2
4
6
8
10
12
14
True SWH, m
Cycle 050
Cycle 100
Cycle 150
Cycle 200
Cycle 250

Figure 9

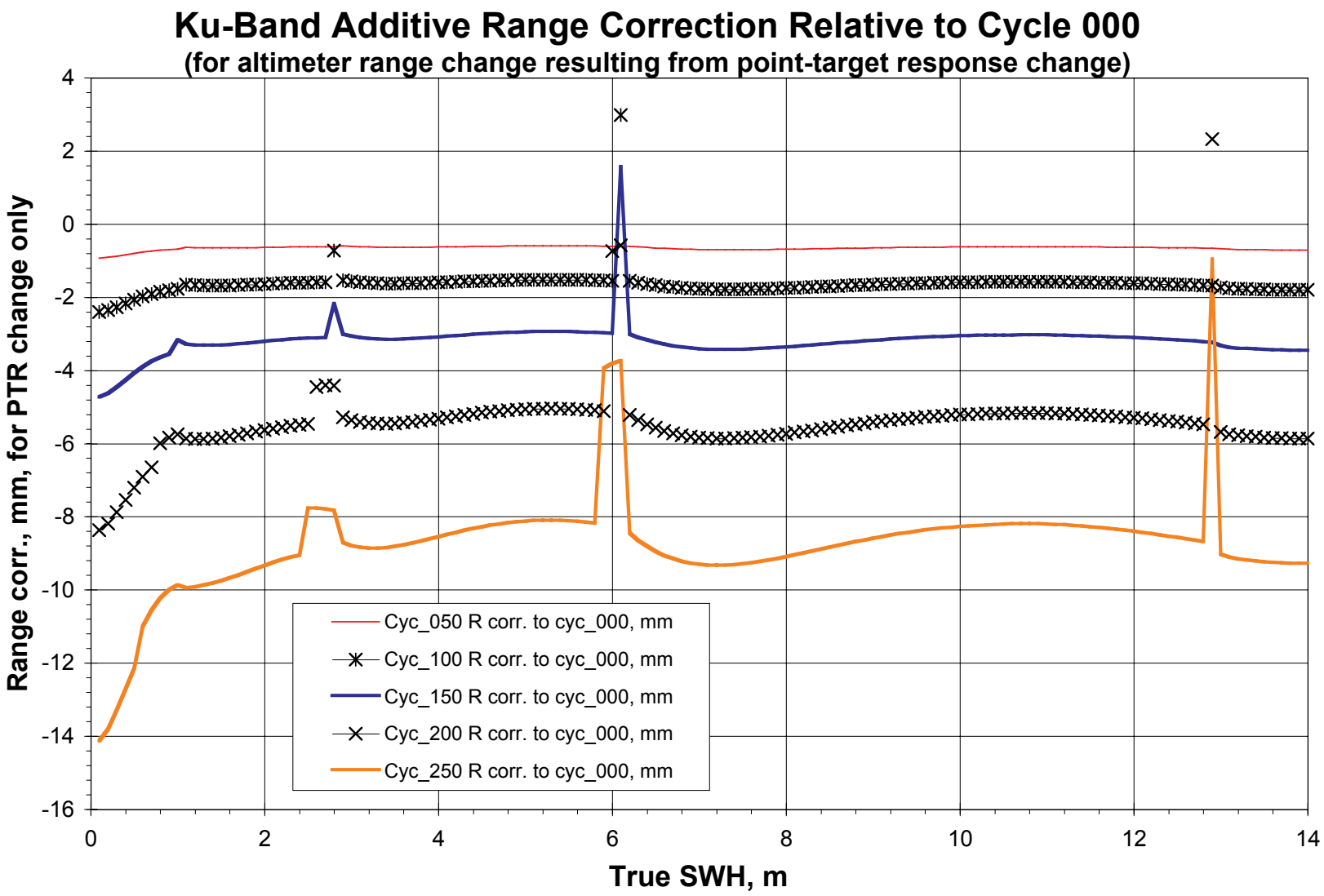
Ku-Band Additive Range Correction Relative to Cycle 000
(for altimeter range change resulting from point-target response change)
Range corr., mm, for PTR change only
True SWH, m
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
2
4
6
8
10
12
14
Cyc_050 R corr. to cyc_000, mm
Cyc_100 R corr. to cyc_000, mm
Cyc_150 R corr. to cyc_000, mm
Cyc_200 R corr. to cyc_000, mm
Cyc_250 R corr. to cyc_000, mm

Figure 10

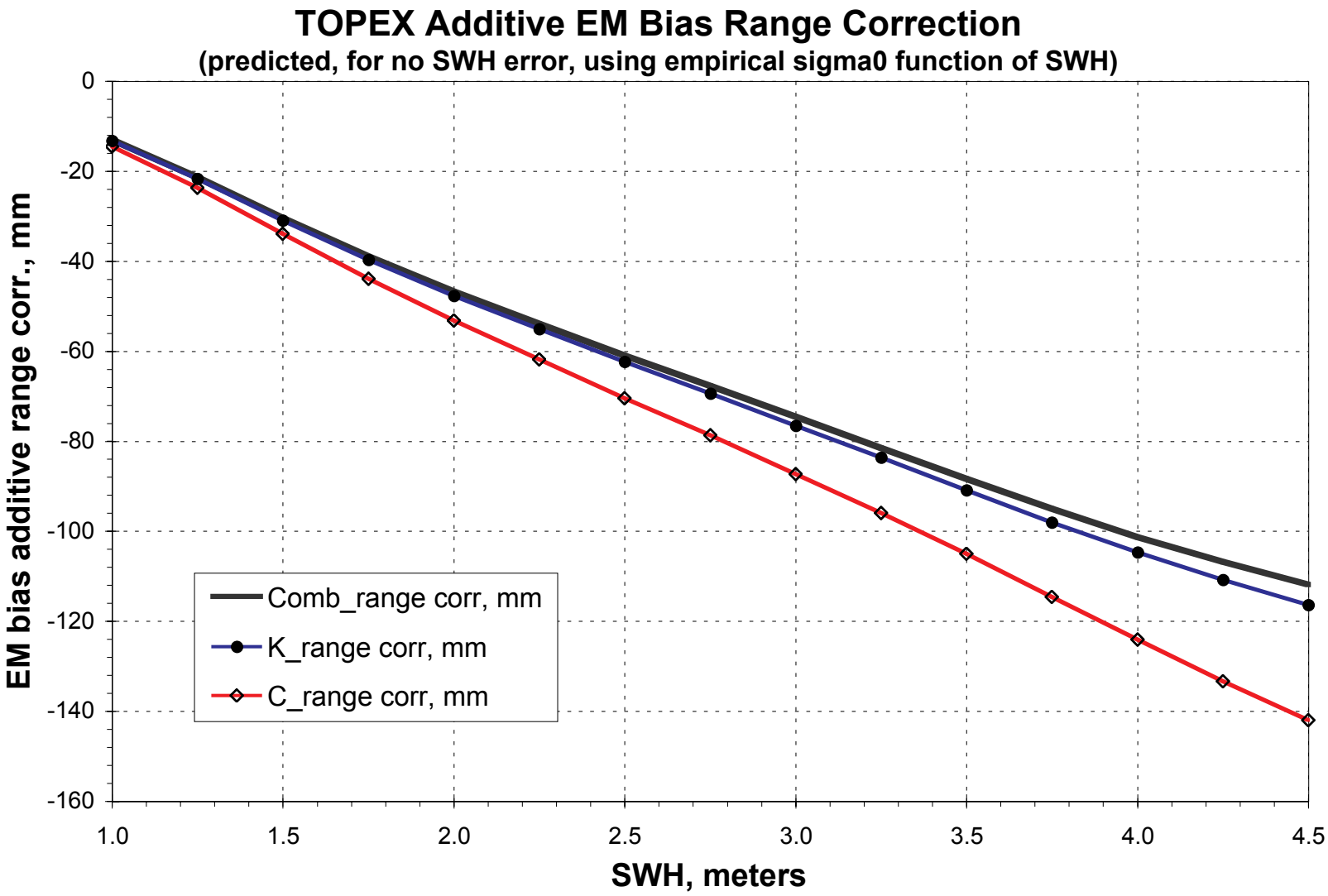
TOPEX Additive EM Bias Range Correction
(predicted, for no SWH error, using empirical sigma0 function of SWH)
EM bias additive range corr., mm
0
-20
-40
-60
-80
-100
-120
-140
-160
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
SWH, meters
Comb_range corr, mm
K_range corr, mm
C_range corr, mm

Figure 11

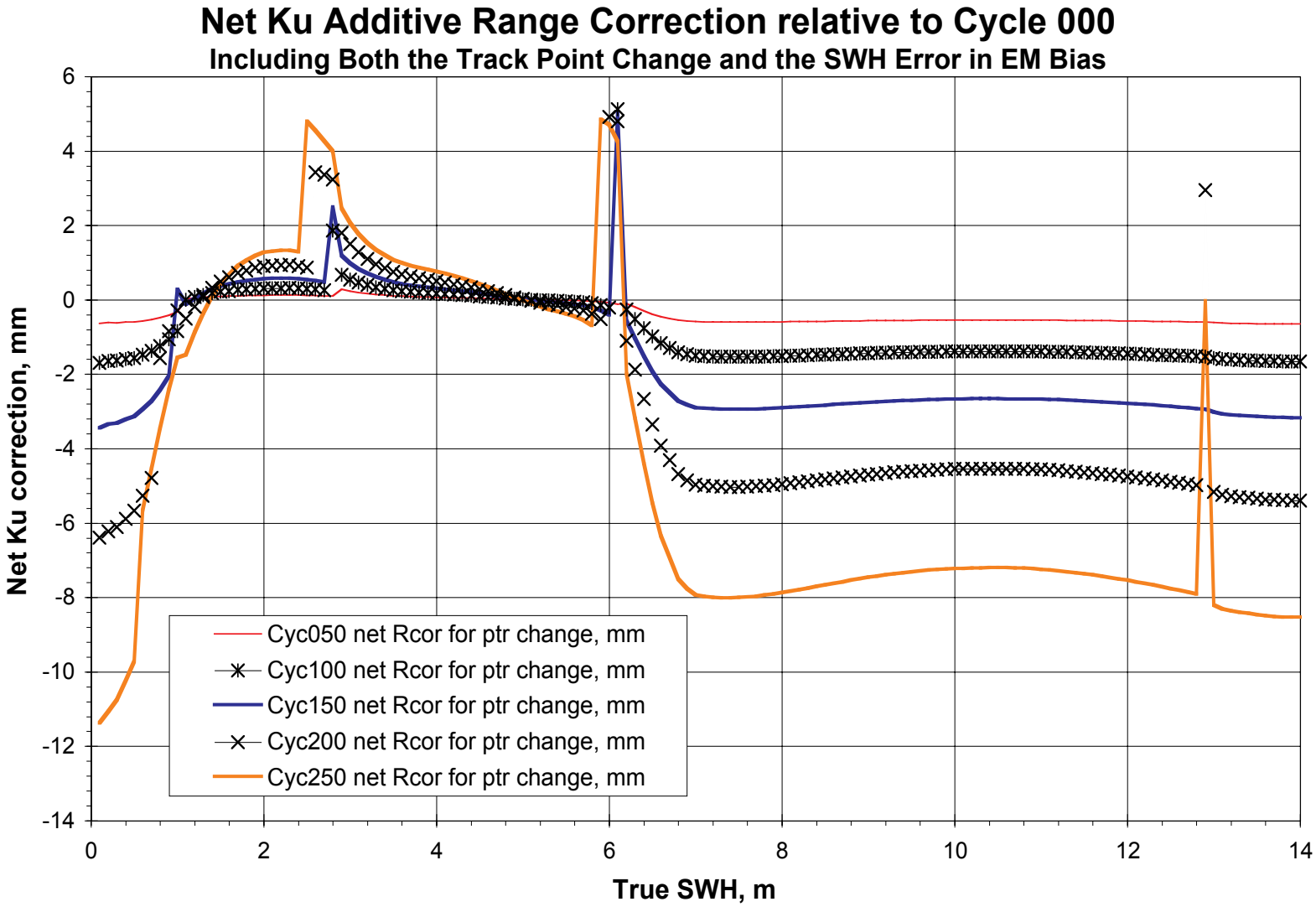
Net Ku Additive Range Correction relative to Cycle 000
Including Both the Track Point Change and the SWH Error in EM Bias
Net Ku correction, mm
True SWH, m
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
0
2
4
6
8
10
12
14
Cyc050 net Rcor for ptr change, mm
Cyc100 net Rcor for ptr change, mm
Cyc150 net Rcor for ptr change, mm
Cyc200 net Rcor for ptr change, mm
Cyc250 net Rcor for ptr change, mm

Figure 12

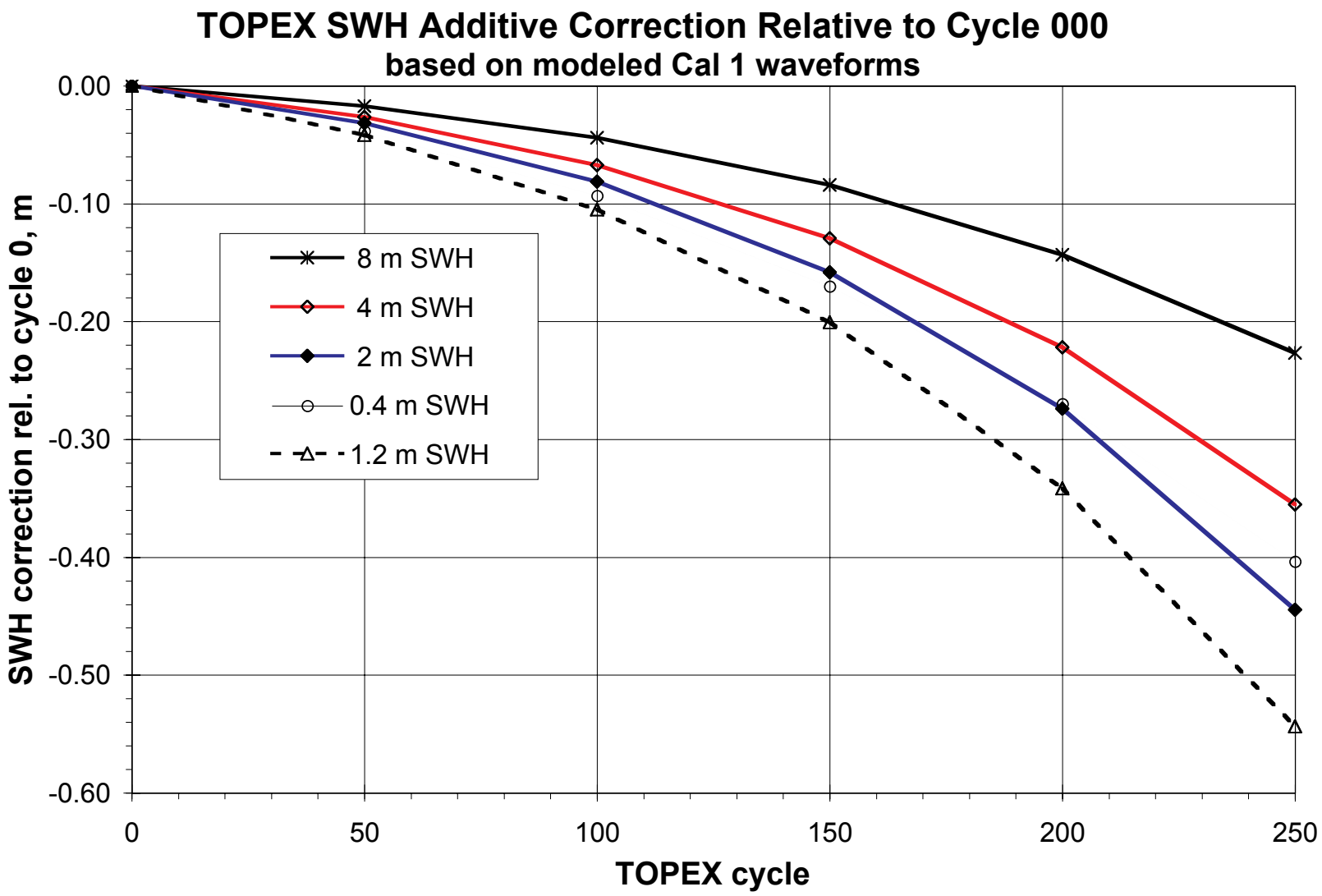
TOPEX SWH Additive Correction Relative to Cycle 000
based on modeled Cal 1 waveforms
SWH correction rel. to cycle 0, m
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
0
50
100
150
200
250
TOPEX cycle
8 m SWH
4 m SWH
2 m SWH
0.4 m SWH
1.2 m SWH

Figure 13

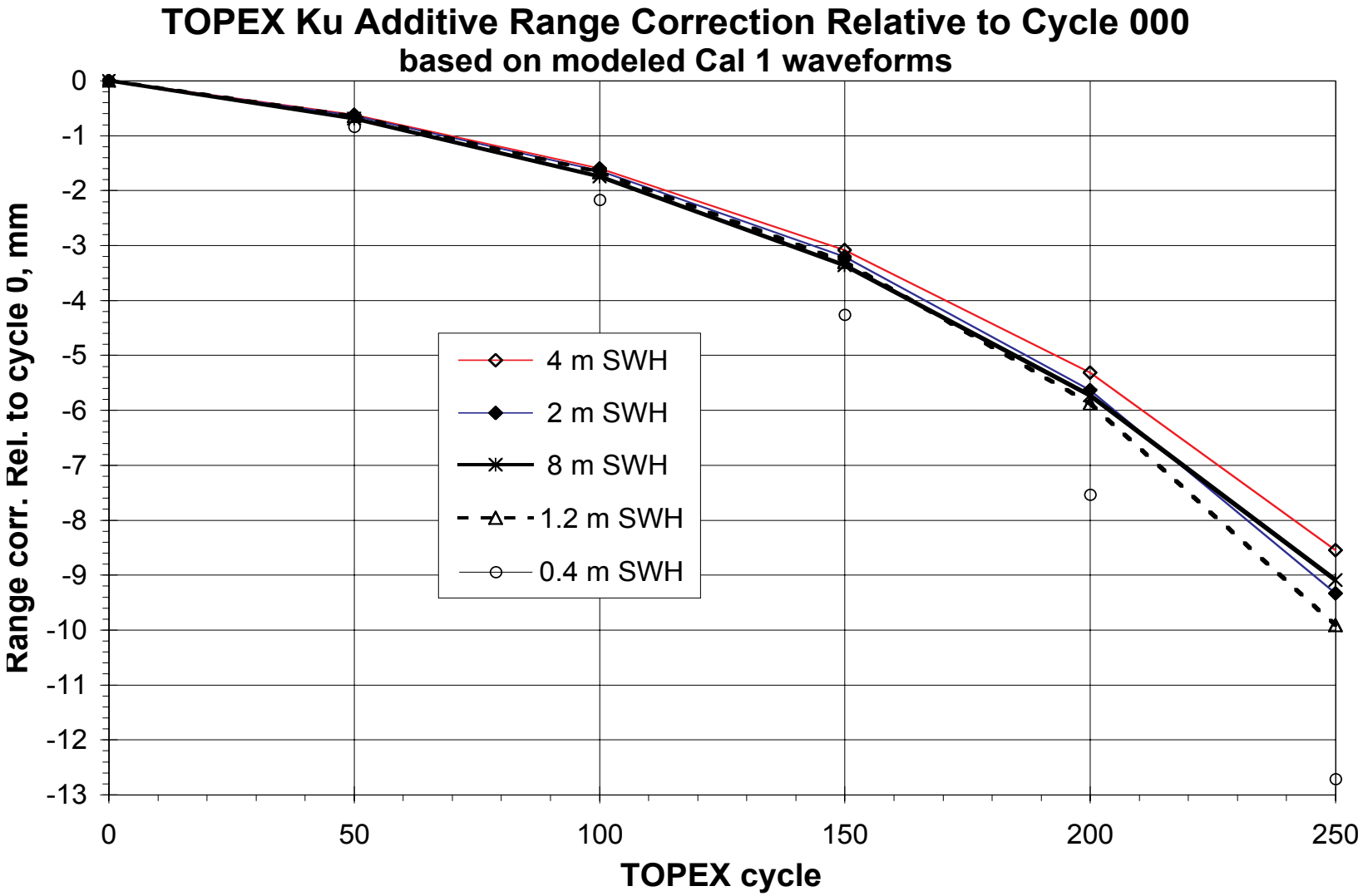
TOPEX Ku Additive Range Correction Relative to Cycle 000
based on modeled Cal 1 waveforms
Range corr. Rel. to cycle 0, mm
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
50
100
150
200
250
TOPEX cycle
4 m SWH
2 m SWH
8 m SWH
1.2 m SWH
0.4 m SWH

Figure 14

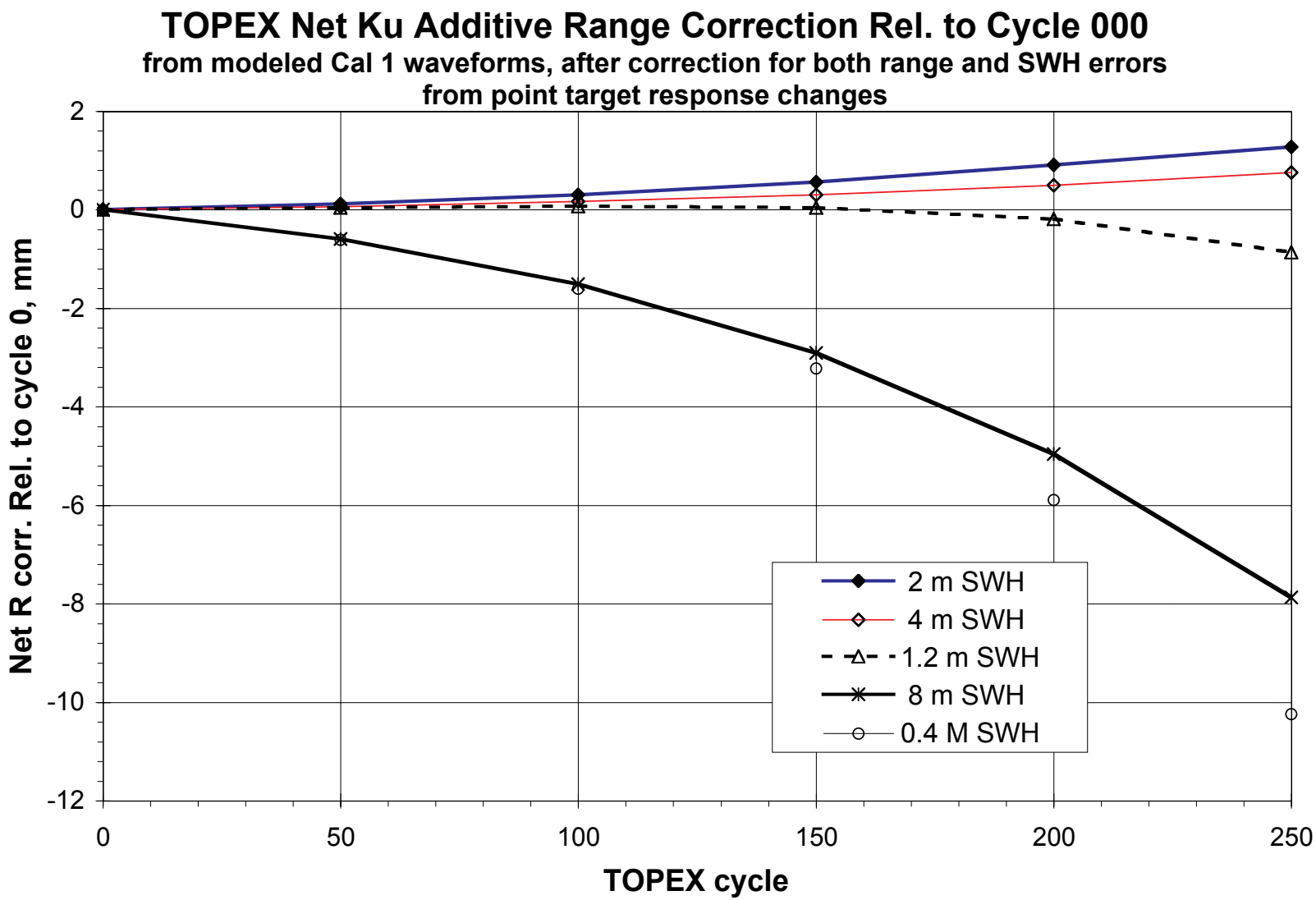
TOPEX Net Ku Additive Range Correction Rel. to Cycle 000
from modeled Cal 1 waveforms, after correction for both range and SWH errors
from point target response changes
Net R corr. Rel. to cycle 0, mm
2
0
-2
-4
-6
-8
-10
-12
0
50
100
150
200
250
TOPEX cycle
2 m SWH
4 m SWH
1.2 m SWH
8 m SWH
0.4 M SWH

Figure 15